Improved 3D Mars Control Net from a Combined Adjustment of VIKING images and Mars Orbiter Laser Altimeter data

J. Heller [1,2] , M. Wählisch [1] , W. Zeitler [3], F. Scholten [1]

[1] German Aerospace Center (DLR),
Institute of Space Sensor Technology and Planetary Exploration, Berlin-Adlershof,
[2] Technical University of Berlin (TUB),
[3] former colleague of the DLR

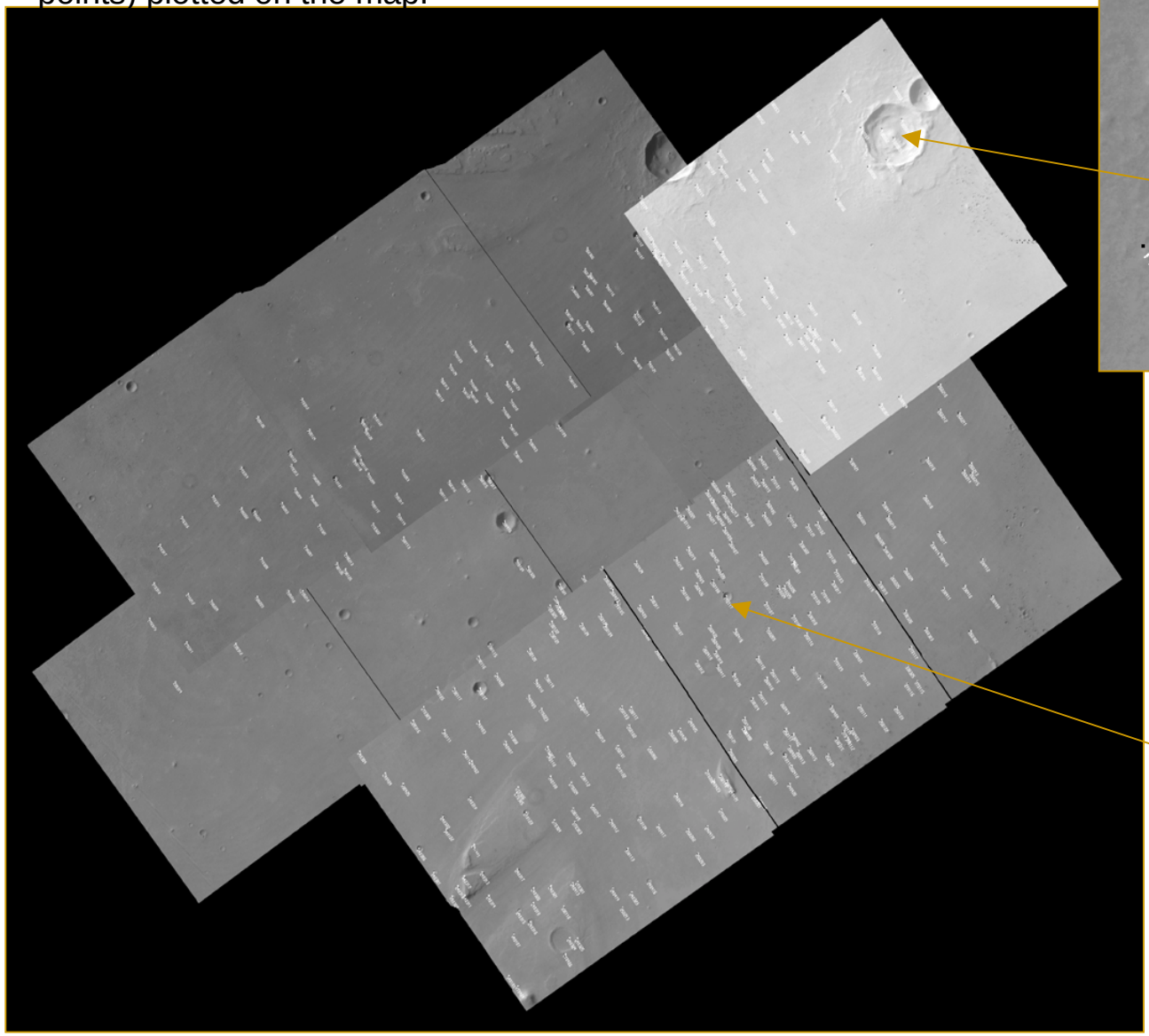
e-mail: marita.waehlisch@dlr.de

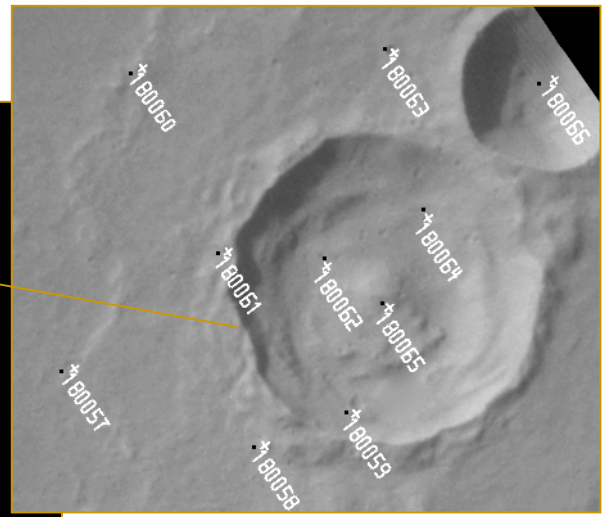
Introduction:

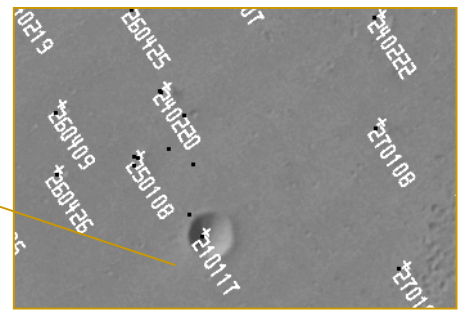
- Viking Orbiters from 1976 to 1980 took about 52,000 images with a resolution ranging from 8m up to more than 1000m/pxl from Mars' surface
- various photogrammetric control point networks from these data established:
    - -> 1977 by Davies, M.E., Rand Corp.
    - -> 1990 by Wu & Doyle, USGS
    - -> 1999 by Zeitler, W., J. Oberst, DLR

- Zeitler network as recomputation of the USGS net:
    - -> simultaneous global bundle block adjustment of selected USGS points and additional points around Pathfinder landing site, measured by Tom Duxbury (JPL)
    - -> encompasses 3739 points in 1138 Viking images and 2 images from Mariner 9 mission
    - -> benefits from Mars Pathfinder as one reliable, well-known ground point providing important tie of the network to the Martian surface
    - -> input data:
        - # manually measured image coordinates
        - # MPF as ground control point in areocentric coordinate system XYZ
        - # inner and outer orientation parameters from instrument kernels. ephemeris and C-kernel (Spice)
        - # occultation measurements (for 246 points) (Smith and Zuber)
    - -> achieved accuracy and results:
        - # mean standard deviation of calculated control points: 740m (690m horizontally and 840m vertically) (as seen on the next page)
        - # coordinates of camera, i.e.. spacecraft position: 4515m
        - # camera pointing angles / spacecraft attitude: 0.051 gon
        - # Orthoimage map of a resolution of 64 pxl/deg composed of included images and calculated with adjusted outer orientation

This map (40 m/pxl) shows the MPF region derived from raw Viking images orthoprojected on a Zeitler-DTM (2 km/pxl resolution, derived from adjusted Zeitler control points) with image coordinates (white crosses) plotted on the raw images and adjusted control points (black points) plotted on the map.







Task:

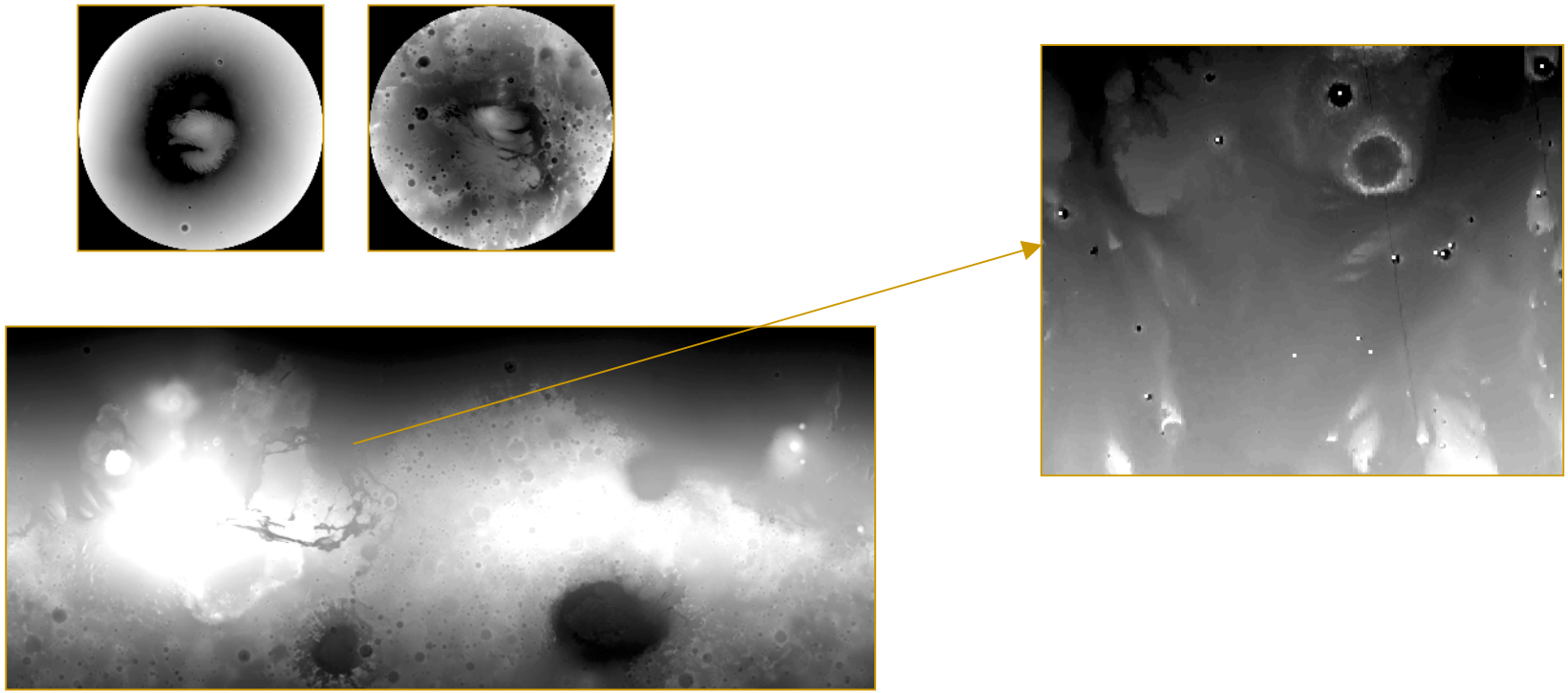
The results of the Zeitler control point net are not consistent with the new MOLA altimeter data collected from the MGS spacecraft, being of excellent accuracy. Therefore, we initiated a new photogrammetric adjustment process of the Zeitler control point net in order to test and to improve the existing network with MOLA height information.

Method:

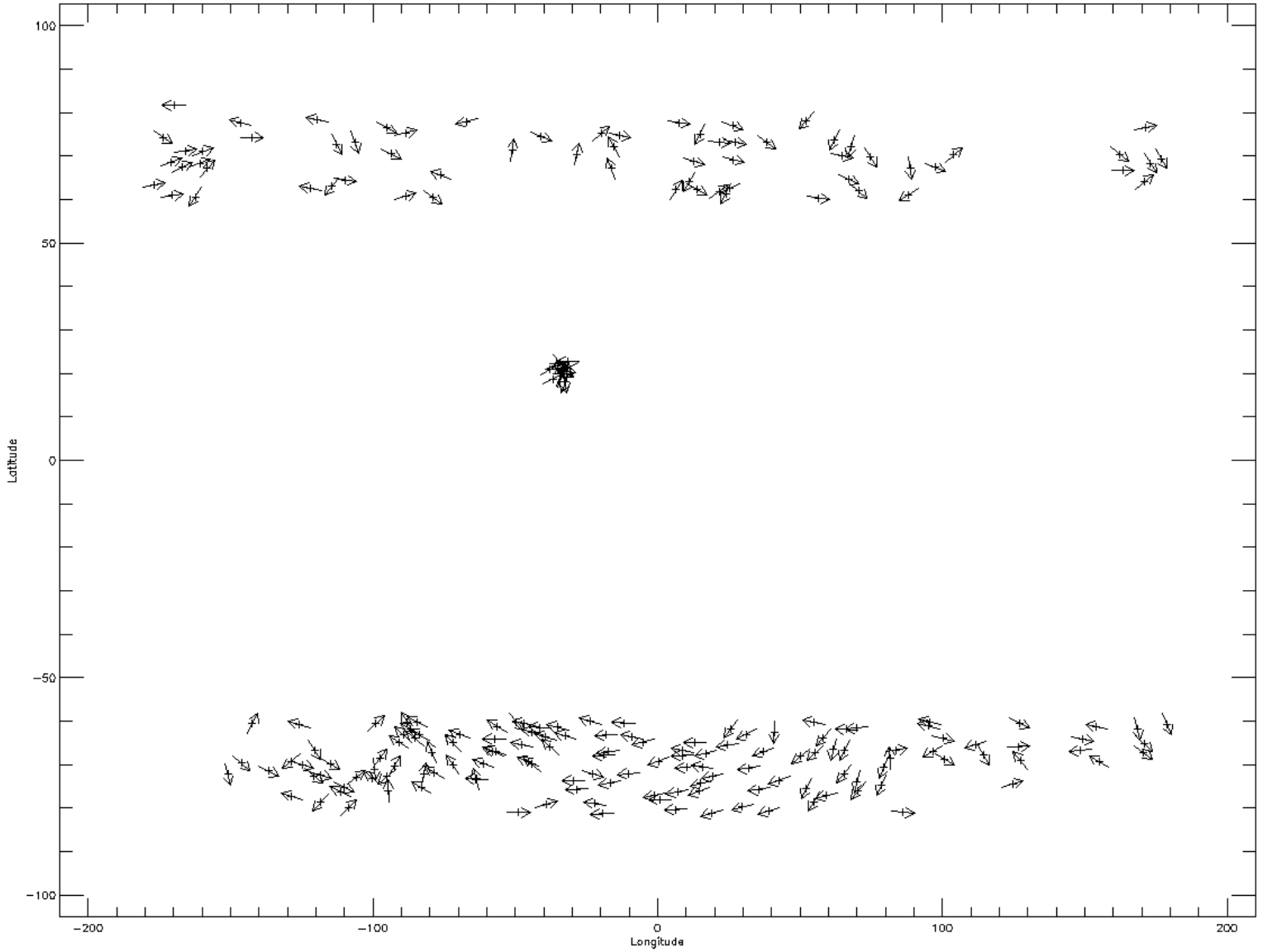
In the photogrammetric processing we include Viking images as well as MOLA "planetary radii" data:

To be able to use the accurate laser altimeter elevation information, a Digital Terrain Model (DTM) in the same reference system of MARS in J2000 as MDIM2 is, was created from so-called planetary radii obtained by MOLA (see next page). Interpolated radii were then extracted for each control point and introduced as additional conditions for the coordinates of each global control point into a combined bundle block adjustment using image coordinates and the navigation data of the spacecraft/camera as observations. The control point coordinates in the areocentric object coordinate system, referenced to the same coordinate system as MDIM2, and the original camera position coordinates and orientation angles, transformed to the reference system of MDIM2, are used as initial values for the unknowns. Necessary coordinate transformations for MPF, object points, and camera positions between IAU94 and the MDIM2 reference system are done using VICAR (Video Image Communication and Retrieval) software, developed at the DLR. The computation of the bundle block adjustment is carried out using the software CLIC, developed at the Technical University of Munich (TUM), department of photogrammetry.

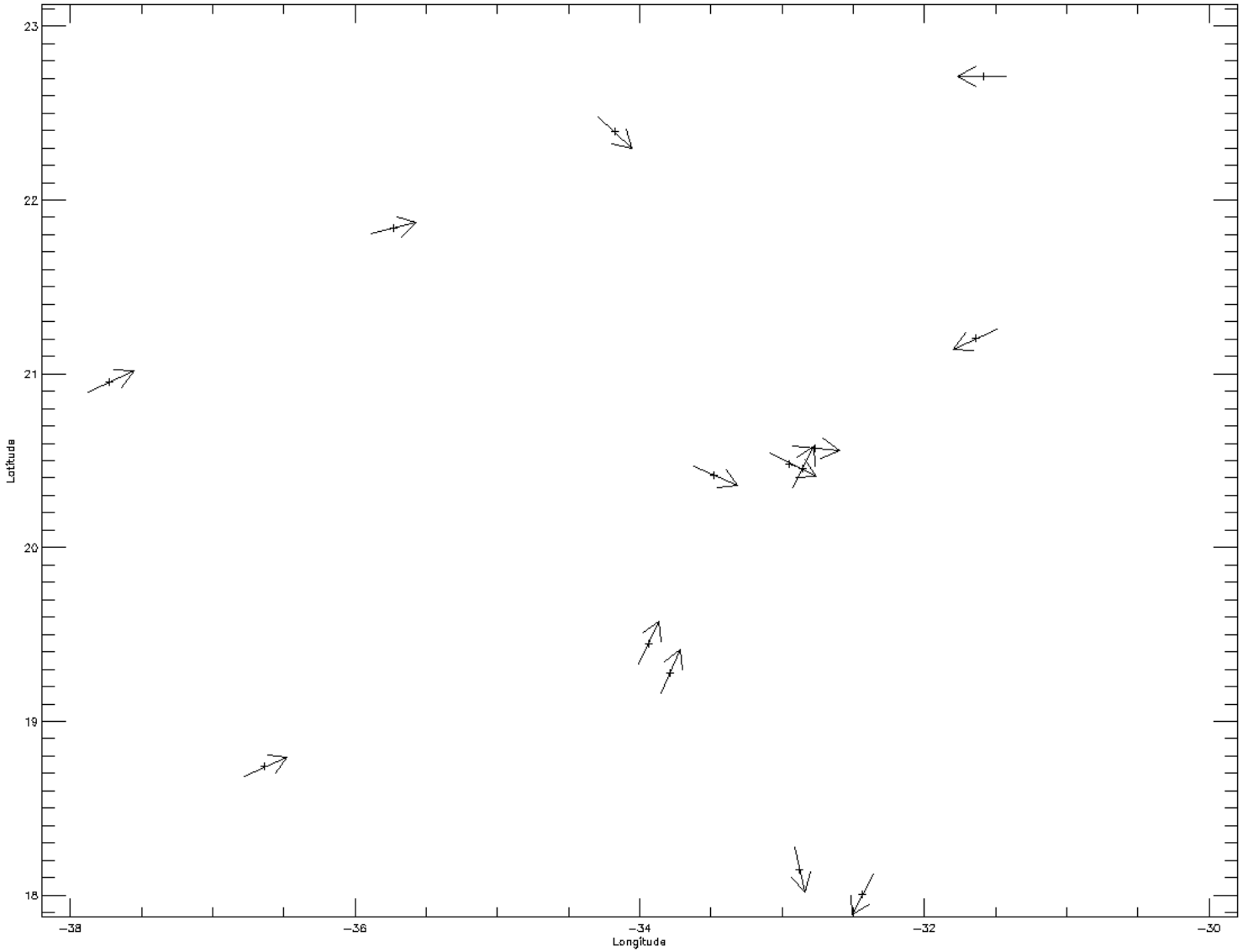
Digital Terrain Models (DTM) of the planetary radii derived from all available MOLA shots



The location of the Zeitler control points as plotted on the radii-DTM is visually checked using the USGS sketches with marked control points in Viking images. We recognized offsets between the plotted white points (latitude, longitude of Zeitler control points) in the radii MOLA-DTM and the topographic features (black craters), which can be explained by missing MOLA height information during the Zeitler adjustment (1999). These offsets are measured and eliminated in the input data for the bundle block adjustment. The displacement of the plotted control points according to the topographic features is visible on the upper right image (MPF landing site).



Displacement of selected control points, plotted on the radii DTM according to the topographic features (North pole, MPF region in the middle and South pole region), eastern longitudes. Arrows are pointing from the old location (latitude, longitude of Zeitler control points) to the MOLA defined location (visible topographic feature in the radii DTM).



Displacement of selected control points in the MPF region, plotted on a radii DTM according to the topographic features, eastern longitudes. Arrows are pointing from the old location (latitude, longitude of Zeitler control points) to the MOLA defined location (visible topographic feature in the radii DTM). The mean of the point displacements amounts to about 1.83 km.

Conclusions:

In preliminary adjustment runs using non-location-corrected planetary radii, the accuracy of the object point coordinates could be improved up to 380 m, which is about half of the current Zeitler point accuracy. We hope to be able to achieve even better adjustment results for both object point coordinates and outer orientation parameters in future by incorporating corrected MOLA-radii for all control points.
We will have the objectives to create a MOLA-consistent accurate orthoimage map of Viking data (resolution of 64 pxl/deg or better) using improved outer orientation parameters and a MOLA-DTM covering the whole planet. We hope to get an important tool for scientific investigations and for the planning of future missions to Mars, e.g. Mars Express, MER.

References:

-Zeitler, W.; J. Oberst, The shape of Mars before Global Surveyor: Results from reanalysis of the Viking control point network, JGR, Vol. 104, No. E6, Pg. 14,051-14,063,1999

-http://wufs.wustl.edu/missions/mgs/mola